DTIC
ELECTE
OCT 18 1990
S D
D

AD-A227 983

Quarterly Progress Report for Contract N00014-90-J-1599

"Modeling Physical Objects"

Christoph M. Hoffmann
Computer Science Department
Purdue University
West Lafayette, Indiana 47907
(317)-494-6185

Period of February through April, 1990

1 Summary of Activities

The two foci of work have been the Newton project, simulating mechanical systems of rigid bodies, and the geometry research. The Newton work made progress in the collision support for arbitrary polyhedral geometries. This work is nearing completion. It was implemented by Bill Bouma and Dr. George Vaněček. For technical details see Section 2.1. The geometry research has concentrated on developing the basic theory and infrastructure for constraint-based surface design using the dimensionality paradigm. For technical details see Section 2.2.

The reports and papers completed during the reporting period are listed below in Section 2.4. Also, I joined the editorial board of the newly founded "International Journal of Computational Geometry and Applications." I prepared the organization of a course on geometric modeling and robotics, to be held in Trento, Italy, in June 1990, as well as the SIGGRAPH '90 Course on unifying parametric and implicit representations. I served on a number of NSF panels to evaluate grant proposals, for the computer science and the engineering divisions of the foundation.

In February, I organized a symposium for the annual meeting of the American Association for the Advancement of Science, entitled "The Computational Paradigm in Science and Engineering." The speakers were Tony Woo from NSF, Greg Schubin from Boeing Computer Services, Jacob Schwartz from the Courant Institute, Melvin Kalos from Cornell's Theory Center, and myself. In April, I attended the Conference "Design and Implementation of Symbolic Computation Systems," in Capri, Italy, for which I served on the program committee. Also, I gave an invited presentation on my geometry research at the NSF Research

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

90 10 10 131

Conference on Geometric Modeling at Wayne State University. See also Section 2.3

2 Technical Details of the Work

2.1 Mechanical Simulation

During the Fall of 1989, Vaněček's ProtoSolid modeling system was incorporated into Newton. ProtoSolid is a polyhedral modeler that Vaněček designed and implemented for his PhD at the University of Maryland, under the direction of Dana Nau. After graduation, Vaněček joined our department as research associate and has been collaborating with me. Incorporation of ProtoSolid into Newton has four aspects.

1. Set up the basic communication protocols and interfaces between Newton and ProtoSolid.
2. Implement mass property calculations so that Newton can work with arbitrary solids defined with ProtoSolid.
3. Devise data structures to support geometric collision detection and analysis.
4. Devise methods to increase the robustness of processing collisions and temporary contacts over time, and preventing drift between contacting bodies.

During the Fall semester of 1989, the first two points were completed. During the reporting period, point 3, collision support was undertaken. To this end, a generalization of binary space partitioning trees was devised that allows efficient interference testing. At the end of the quarter the implementation effort was 80 percent complete. Some complicated collision simulations were demonstrated.

2.2 Geometry Research

In this work I continued to develop the dimensionality paradigm. Briefly, surfaces required to satisfy certain constraints of distance, curvature, position, or other shape parameters are represented as sets of nonlinear equations, where the additional equations expresss the constraints. Rather than eliminating the additional equations, a truly mammoth task well beyond the capabilities of machines, I deal with the set of equations directly, thereby shifting the border between symbolic and numerical computation closer to the problem formulation. This can be conceptualized as viewing the surface in a higher-dimensional space.

A similar idea is under development by Canny and Manocha for the conversion between parametric and implicit surfaces. They also propose to bypass extensive symbolic computations in favor of shifting the numerical computations closer to the problem formulation.

Together with Jung-Hong Chuang I worked on a uniform surface evaluation algorithm. This algorithm refines the approach used in the surface intersection trace algorithm developed two years ago in collaboration with Bajaj, Hopcroft and Lynch. The refinement adds important global elements by integrating ideas developed by Allgower and Gnutzmann.

Together with Ching-Shoei Chiang I worked on the initial-points problem. Given a surface or curve defined as a set of nonlinear equations, within a domain, the objective is to locate domain points that lie on the surface or curve. Our approach explores generalizations of the successful domain-reduction and subdivision methods developed in CAGD for parametric surfaces. Since the nonlinear equations need not represent parametric hypersurfaces, our approach is to increase the dimension by 1 and to work with the graph of the hypersurface:

$$f(x_1, ..., x_n) = 0 \qquad \Longrightarrow \qquad z = f(x_1, ..., x_n)$$

Note that the graph $z = f(x_1, ..., x_n)$ is always parameterizable, thus can be expressed in Bernstein-Bèzier form. Thus, convex-hull properties are realized that can be exploited in generalizations of the subdivision methods developed by CAGD.

2.3 Talks, Workshops and Conferences

For the annual AAAS meeting in February I organized the symposium "The Computational Paradigm in Science and Engineering". The symposium examined the emerging role of computational science. Tony Woo described the support given to the development of the paradigm by the National Science Foundation. Greg Schubin from Boeing explained the past, present and future role of computational fluid dynamics in commercial aircraft design. Melvin Kalos from Cornell drew an analogy with statistical mechanics to support his thesis that computational science will effect a close integration between the different scientific disciplines. I explained the role of mechanical simulation and described the Newton project. Jacob Schwartz from the Courant Institute was to talk about neural computing. Caught in a snow storm, he could not attend, however.

The conference on design and implementation of symbolic computation systems was a forum for implementors of symbolic computation systems, organized by Alfonso Miola from the University of Rome, Italy. It was well attended by researchers and developers from Europe and North America, and there will be a second conference on the subject next year in Bath, England, organized by James Davenport. The total number of submissions was approximately 110 of which about 40 papers were accepted.

The NSF research conference on geometric modeling in Detroit was a follow-up of a prior conference three years ago. As for its predecessor, the goal was to increase the dialogue between academia and industry. I spoke on the dimensionality paradigm stressing its potential for precision design of complex surfaces.

2.4 Reports and Publications

1. "Variable Radius Blending Using Dupin Cyclides," in *Geometric Modeling for Product Engineering*, K. Preiss, J. Turner, M. Wozny, eds., North Holland, 1990, 39–58; (with V. Chandru and D. Dutta)

2. "Visualization of Surfaces in Four-Dimensional Space," Report CAPO-90-12, Comp. Sci., Purdue Univ; (with J. Zhou).

3. "Conversion Methods between Parametricand Implicit Curves and Surfaces," Report CAPO-90-18, Comp. Sci., Purdue Univ.

Accesion For

NTIS CRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification

By per call
Distribution /

Availability Codes

Dist	Avail and / or Special
A-1	

STATEMENT "A" per Dr. Ralph Wachter
ONR/Code 1133
TELECON 10/17/90 VG